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Comprehensive review on *Syzygium cumini*

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Abstract: Syzygium cumini (L.) Skeels, commonly known as Jamun or black plum, is an evergreen tree belonging to the Myrtaceae family with a wide distribution across Asia, Africa, and South America. Various parts of the plant, including fruits, seeds, bark, and leaves, are rich in phytochemicals such as alkaloids, flavonoids, tannins, phenolic compounds, and essential oils. Traditionally, it has been an integral part of Ayurvedic, Unani, and Siddha medicine for treating ailments like diabetes, diarrhoea, dysentery, sore throat, asthma, and ulcers. Ethnopharmacological studies validate its antidiabetic, antimicrobial, antioxidant, anti-inflammatory, anticancer, antifungal, hepatoprotective, cardioprotective, anti-allergic, anticlastogenic, anti-diarrheal, anti-fertility, and antiviral properties. Seeds in particular have shown promising activity against diabetes and microbial infections, while fruits and leaves contribute significant antioxidant and cardioprotective effects. The presence of diverse bioactive constituents and broad pharmacological potential underscores the medicinal importance of Syzygium cumini and supports its continued use in traditional and modern medicine.

Index Terms: *Syzygium cumini,* Syzygium jambolanum, Jamun, Antioxidant, Antimicrobial, Pharmacological action

1. INTRODUCTION

Syzygium cumini (S. cumini) (L.) Skeels (family: Myrtaceae), synonyms- Syzygium jambolana DC., Eugenia cumini (Linn.) Druce., Syzygium jambolanum (Lam.) DC., Myrtus cumini Linn., Eugenia djouant Perr., Eugenia caryophyllifolia Lam., Calyptranthes jambolana Willd., The English word for it is Black Plum, the Hindi word is Jamun, the Sanskrit word is Jambu, and the Urdu word is Jaman. It is a large evergreen tree that grows naturally in India, but *Syzygium cumini* (SC) trees can be found all over the Asian subcontinent, South America, Eastern Africa, Madagascar, and more (Li et al., 2009).

Various components have been documented in different parts of plants. There are vitamins A and C, nicotinic acid, riboflavin, folic acid, maleic acid, choline, sugar, amino acids, K, Ca, Na, P, Fe, Mn, and Zn in the fruit pulp. Some people say that gallic acid is what makes the fruit sour. while anthocyanins give it its color. The leaves are full of acylated flavonol glycosides, myricetin, myricitin, quercetin, galloyl carboxylase, esterase, and tannins. Quercetin, kaempferol, myricetin, oleanolic acid, quercetin-3-D-galactoside, eugenol-triterpenoid A & B are all found in the flowers. Flavonoid glycosides and isorhamnetin 3-O-rutinoside are found in the roots. There are betulinic acid, β-sitosterol, quercetin, kaempferol, ellagic acid, gallic acid, myrecetin, and other things in the stem

bark. The seeds have glycoside jambolin, gallic acid, essential oils, and other things in them (Ayyanar et al., 2012).

Historically, the tree's various parts have been used to treat a range of human illnesses. SC has a place in many traditional medical systems, including homeopathic, Siddha, Ayurvedic, and Unani. Prior to the discovery of insulin, it was one of the most effective treatments for diabetes (Helmstädter, 2007).

The barks of SC have astringent, acrid, digestive, and wound-healing qualities, according to Ayurveda. Biliousness, dysentery, sore throat, bronchitis, thirst, asthma, and ulcers can all be effectively treated with them. The Siddha medical system states that it should be hypothermic, haematinic, and semen-promoting. According to the Unani medical system, it strengthens teeth and gums, enriches blood, and acts as a liver tonic (Wahane et al.,2019).

2. HABITAT AND GEOGRAPHICAL DISTRIBUTION:

Syzygium cumini which is also known as Eugenia cumini, Eugenia jambolana, jambul, or black plum, is a species of the family Myrtaceae, and its natural distribution is within the continent of Asia (Chaudhuri et al., 1990).

For India, it is one of the significant indigenous species which has been known and appreciated for its medicinal and ecological value. This tree species has a good degree of adaptability and can be found all over the country, having been utilized by traditional medicine systems which use the stem bark, leaves, and seeds for a number of medicinal treatments (Kumar et al., 2008).

Its widespread occurrence across the plains and cultivated areas reflects adaptability to the local climatic conditions and the ability to grow in a wide range of environmental conditions. The seeds and other plant parts required for pharmacological research are easily collected in the case of Syzygium cumini, which highlights that this species is readily available in the wild (Bhuiyan et al., 1996).

Its distribution in other parts of Asia indicates that the species is well established in the tropical region, where the ecological conditions are favourable (Kusumoto et al., 1995).

The tree's persistent use in indigenous medicine has also fostered its distribution in the rural and semi-urban areas, providing easy access to wild and cultivated sources (Slowing et al., 1994).

Syzygium cumini continues to be widely distributed species of Asia, growing in varied habitats and sustaining its traditional as well as modern relevance (Muruga Nandan et al., 2001).

1. 3. TRADITIONAL AND ETHNOPHARMACOLOGICAL USES:

3.1 Traditional Uses of *Syzygium cumini*

Syzygium cumini has been extensively used in traditional medicine systems such as Ayurveda, Siddha, and Unani for managing various ailments (Kartika & Basu, 1987).

The bark has long been valued for its astringent and digestive properties and is employed in conditions like diarrhoea and dysentery Seeds are traditionally used for controlling excessive thirst and urine output in diabetes, a practice still followed in rural communities (Azadeh et al., 2023).

The leaves are known for their soothing effect and are used in the management of leucorrhoea, constipation, and skin disorders. Fruits, being both nutritive and therapeutic, are consumed for relief from spleen enlargement, pharyngitis, and to promote cooling during summer seasons (Warrier, 1993).

These uses highlight how the plant has been deeply embedded in daily healthcare and cultural practices over generations (Ethnobotany, 2017).

3.2 Ethnopharmacological Uses of *Syzygium cumini*

Ethnopharmacological research has validated many traditional claims, revealing the plant's diverse bioactivities (Achrekar et al., 1991).

Seed extracts have demonstrated significant antidiabetic and hypoglycaemic effects in experimental studies, supporting their traditional role in managing diabetes (Bhuiyan et al., 1996).

The plant also exhibits antimicrobial activities, with extracts from seeds, bark, and leaves showing action against bacterial and fungal strains (Harishkumar et al., 2020).

Antioxidant activity has been widely reported, attributed to the phenolic and flavonoid content of its fruits and seeds. Furthermore, hepatoprotective and cardioprotective properties have been documented, with extracts protecting against chemical-induced liver damage and oxidative stress in heart tissues . Other reported activities include anticancer and anti-inflammatory effects, indicating its broader therapeutic relevance (Bopp et al., 2009). Thus, ethnopharmacological evidence strengthens the traditional use of *Syzygium cumini* while also expanding its scope in modern medicine (Ayyanar et al., 2012).

2. 4. CHEMICAL COMPOSITION:

The study confirmed that *Syzygium cumini* is rich in various bioactive compounds. Seeds stood out for their strong presence of alkaloids, carbohydrates, tannins, and phenols, explaining their medicinal use. Leaves showed plenty of secondary metabolites like saponins, flavonoids, and tannins, giving them therapeutic value. Bark contained proteins and flavonoids, which contribute to its traditional role in treating throat and bowel problems. Roots had fewer active compounds, but still tested positive for carbohydrates and flavonoids, showing that all parts of the plant have pharmacological potential (1) (Prabhakaran et al., 2011).

Table 01: Phytoconstituents Group (Prabhakaran et al., 2011)

S No	Plant Part	Chemical Constituents Identified
01	Seed	Presence of alkaloids (Wagner's), carbohydrates (Fehling's, Barford's, Benedict's), oils, tannins, phenols, and flavonoids detected.
02	Leaf	Showed carbohydrates, saponins, oils, gums, tannins, phenols, and flavonoids, but alkaloids mostly absent.
03	Bark	Contained carbohydrates, proteins (biuret test), oils, tannins, phenols, and flavonoids, with weak gum presence.
04	Root	Positive for carbohydrates, flavonoids, and some alkaloids, though overall fewer constituents compared to seed and leaf.

5. PHARMACOLOGICAL ACTIVITIES:

5.1. Antimicrobial Activity:

Safer new antibacterial agents are needed because people have started using antibiotics as OTC (over-the-counter) medications, which has resulted in antibiotic resistance. Regarding SC, it was discovered that its fruit, leaf, and stem extracts were efficient against every bacterial strain utilized in the Research. The best outcomes were seen against Roultella plantikola (25 mm zone of inhibition) (Meena et al., 2023).

The antibacterial properties of SC seeds against multidrug-resistant human bacterial pathogens were investigated using microbroth dilution and Agar well diffusion assays. The most effective fraction from the ethanol extract was discovered to be ethyl acetate. Next, the fraction of ethyl acetate was TLC-bioautography and phytochemical analysis revealed that the primary ingredient causing the activity was phenolics (Bag et al., 2012).

5.2. Antioxidant Activity:

The antioxidant activity of *Syzygium cumini* has been extensively studied, with different parts of the plant showing strong free radical scavenging abilities. The seeds are particularly rich in phenolic compounds and flavonoids, which play a major role in their antioxidant potential. In assays such as DPPH and ABTS, methanolic seed extracts displayed a clear dose-dependent radical neutralising effect, with results comparable to those of standard antioxidants like ascorbic acid, emphasizing the importance of their high phenolic content. Beyond the seeds, the fruit pulp and leaves also contribute significantly, with anthocyanin-rich fruit extracts effectively scavenging superoxide and hydroxyl radicals and thereby lowering oxidative stress markers in vitro. The leaves, containing notable levels of quercetin, kaempferol, and myricetin, enhance this protective profile by offering both radical scavenging and metal-chelating activity. Mechanistically, these effects are linked to the abundance of polyphenols, which can donate hydrogen atoms or electrons to stabilise reactive oxygen species. This action helps prevent oxidative damage to essential biomolecules, including lipids, proteins, and DNA, which are otherwise vulnerable to peroxidation and fragmentation under oxidative stress conditions (Ruan et al., 2008).

5.3. Anti-Inflammatory Activity:

Syzygium cumini seeds show significant anti-inflammatory activity, supporting their traditional use against inflammatory disorders. In carrageenan-induced paw edema in Wistar rats, methanolic extract (250 mg/kg) reduced edema by 48.29%, while the aqueous extract achieved 68.85% inhibition, close to diclofenac sodium (75.08% at 100 mg/kg). The stronger effect of aqueous extract suggests a major role of water-soluble constituents. Phytochemicals like tannins, flavonoids (quercetin), and phenolics (gallic, ellagic acid) modulate cyclooxygenase and lipoxygenase pathways, reducing prostaglandin and leukotriene synthesis. Unlike NSAIDs, which cause gastrointestinal side effects, S. cumini offers a safer herbal alternative with promising therapeutic potential in inflammation management (Modi et al., 2010).

5.4. Antifungal Activity:

The antifungal potential of *Syzygium cumini* has gained considerable attention, with different plant parts showing inhibitory effects against a range of pathogenic fungi. Methanolic and aqueous extracts of the seeds, leaves, and bark have been tested against clinically important fungal strains such as *Candida albicans*, *Aspergillus Niger*, and *Trichophyton rubrum*, which are well known for causing opportunistic systemic and superficial infections, especially in immunocompromised individuals. Results consistently indicate that methanolic extracts display stronger antifungal activity than aqueous preparations, likely due to the better solubility of phenolics and flavonoids in organic solvents. In agar diffusion assays, seed extracts produced marked zones of inhibition against *C. albicans*, a leading cause of oral and genitourinary candidiasis, while also showing activity against *A. niger* and *T. rubrum*, pointing to broad-spectrum efficacy against both yeast and filamentous fungi. Mechanistic insights suggest that the antifungal effects arise from disruption of fungal cell membrane integrity and inhibition of ergosterol biosynthesis, processes that compromise membrane stability, increase permeability, and ultimately result in cell death. These actions are closely linked to the plant's diverse phytoconstituents, including tannins, flavonoids, and terpenoids. Tannins may exert fungistatic effects by precipitating fungal proteins, flavonoids can chelate essential minerals and impair enzymatic function, and triterpenoids such as botulinic acid and lupeol are thought to enhance overall antifungal potency through synergistic interactions (Shafi et al., 2002).

5.5. Anticancer Activity:

Syzygium cumini has strong anticancer potential supported by in vitro and in vivo research, with different plant parts showing cytotoxic and chemopreventive properties mainly due to anthocyanins, ellagic acid, and flavonoids. Seed and fruit extracts demonstrated antiproliferative activity against breast, lung, and cervical cancer cell lines, where methanolic seed extracts reduced cell viability dose-dependently and induced apoptosis-related morphological changes. Flow cytometry confirmed G_2/M phase arrest, indicating disruption of DNA replication and mitotic progression, while mitochondrial dysfunction, cytochrome c release, and caspase activation further supported programmed cell death. In vivo studies validated these effects, showing reduced tumor burden and slower progression of chemically induced cancers. The chemopreventive role is linked to antioxidant polyphenols that neutralize reactive oxygen species and prevent oxidative DNA damage, while anthocyanins and ellagic acid modulate NF-κB and MAPK pathways to suppress inflammatory mediators. Importantly, extracts show selective toxicity toward cancer cells while sparing normal tissues (Baliga et al., 2011).

5.6. Antidiabetic Activity:

Syzygium cumini exhibits strong antidiabetic potential, traditionally used in Ayurveda, Unani, and Chinese medicine and now supported by modern research. Seed, fruit, and bark extracts significantly reduce blood glucose and glycosuria, with animal and preliminary human studies confirming antihyperglycemic effects. Ethanolic seed extracts lowered blood glucose by up to 20% in glucose-loaded rabbits, while diabetic rat models showed reduced fasting sugar, improved insulin secretion, and protection of pancreatic β-cells, evidenced by preserved islet structure. Active phytochemicals glycosides, alkaloids, flavonoids, and tannins enhance glucose uptake, inhibit carbohydrate-digesting enzymes, and regulate metabolism. Antioxidants further reduce oxidative stress, enhance protective enzymes, and limit diabetes-related complications.[27]

5.7. Hyperlipidaemia and Cardioprotective Activity:

Syzygium cumini plays a significant role in controlling hyperlipidaemia and supporting cardiovascular health, with seeds and leaves showing the most prominent effects. Ethanolic seed extracts reduce serum cholesterol, triglycerides, and LDL while increasing HDL, indicating improved lipid metabolism and cholesterol clearance.

Its cardioprotective activity is attributed to polyphenols and flavonoids that scavenge reactive oxygen species, enhance antioxidant enzymes, and prevent LDL oxidation, thereby reducing plaque formation and vascular damage. Anti-inflammatory effects stabilize membranes and suppress mediators, protecting cardiac function. In vivo studies reveal protection against myocardial injury, while anthocyanin-rich pulp improves endothelial function, nitric oxide release, vasodilation, and overall circulation (Singh et al., 2016).

5.8. Anti-allergic:

An allergy occurs when the body reacts abnormally to an allergen that is introduced through skin contact, inhalation, injection, or ingestion. For this condition, a new, secure, and efficient treatment is needed. Rat paw edema was inhibited in an investigation by an aqueous extract of SC leaves (25–100 mg/kg, p.o.). caused by 5-HT, histamine, and 48/80 (allergenic compound). Nevertheless, the extract had no positive effects on paw edema brought on by platelet aggregating factor (Brito et al., 2007).

5.9. Anticlastogenic:

An anticlastogenic agent is one that prevents chromosome disruption or breakage. SC extract has shown promise in preventing mutagenesis and initiating carcinogenesis. The hydroxyl radical-induced strand breaks in pBR322 DNA were lessened by the alcoholic seed extractin DBMA and urethane-induced chromosomal abnormalities in mice were found to be lessened by the aqueous extract in vitro (Arun et al., 2010).

5.10. Anti-diarrheal:

The preferred medication for conditions like diarrhea is a natural product. When given orally to rats, SC ethanolic extract (400 mg/kg) has been shown to decrease gastrointestinal activity in PGE2-induced enteropooling and castor oil-induced diarrhea (Mukherjee et al., 2011).

5.11. Anti-fertility:

According to a review, oleanolic acid, a phytoconstituent that was separated from SC flowers, may be able to stop spermatogenesis, which would have an anti-fertility effect on male albino rats (Baliga et al., 2011).

5.12. Antiviral:

There is a need for a safer, non-toxic treatment because new viral diseases are being discovered as a result of environmental change. The antiviral potential of SC leaves and bark aqueous extracts, both hot and cold, was assessed against the avian influenza virus H5N1, which causesa highly contagious disease of poultry by determining the extracts' virucidal, pre-exposure, and post-exposure potential using the CPE reduction assay. In the virus yield reduction assay and the egg-based in ovo assay, 100% virus inhibition was noted with hot and cold aqueous bark extracts and hot aqueous leaf extracts. Bark's CC50/EC50 (selective index) for cold aqueous extract (43.5) and hot aqueous extract (248) demonstrated their effectiveness against the H5N1 virus (Bhanuprakash et al., 2008).

6.Conclusion

Syzygium cumini (L.) Skeels, widely known as Jamun or black plum, is an evergreen tree of the Myrtaceae family with broad geographical distribution and longstanding traditional medicinal value. The plant is a rich source of diverse phytoconstituents such as alkaloids, flavonoids, tannins, phenolics, glycosides, and essential oils, distributed across seeds, bark, leaves, and fruits. These bioactive compounds underpin the wide array of pharmacological properties attributed to the plant. Extensive research has validated its traditional uses, demonstrating significant antimicrobial effects against multidrug-resistant bacteria, notable antifungal activity against pathogenic strains including *Candida albicans* and *Aspergillus niger*, and strong antioxidant potential derived from phenolic and flavonoid-rich extracts that neutralize free radicals and protect biomolecules. Collectively, these findings confirm that the therapeutic relevance of S. cumini extends from ethnomedicine into modern pharmacological research. Its well-documented chemical diversity and broad-spectrum biological activities highlight its potential as a valuable natural resource for developing safe and effective therapeutic agents.

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